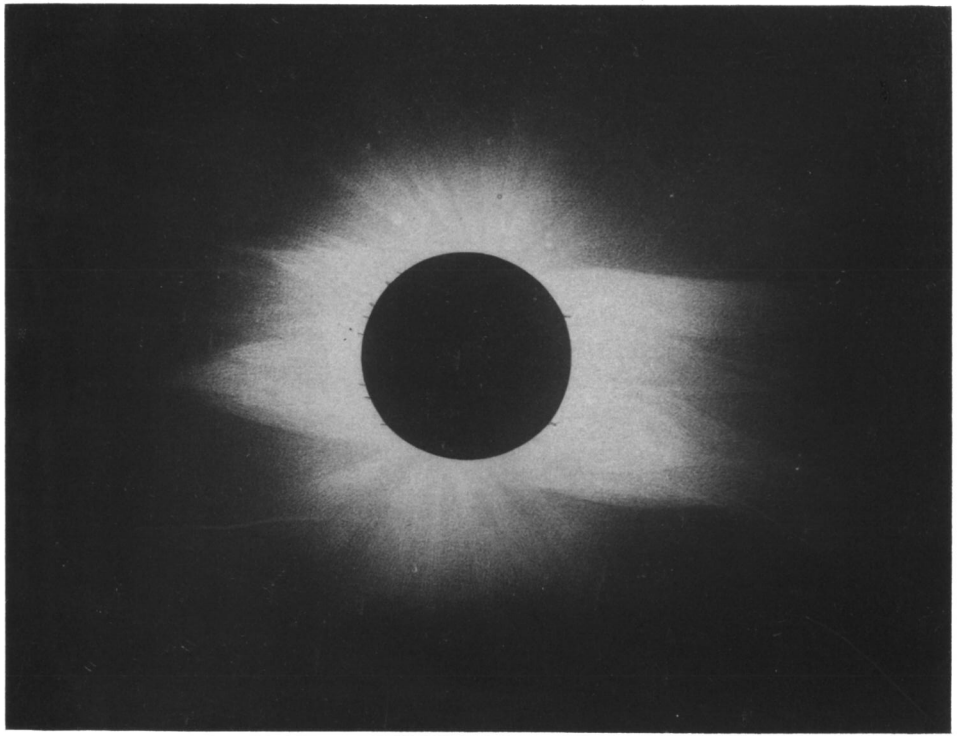

THE CORONA.

FROM PHOTOGRAPHS BY WASHINGTON UNIVERSITY ECLIPSE PARTY.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, JUNE 13, 1891. NO. 16.

THE SOLAR CORONA OF JANUARY, 1889, FROM THE PHOTOGRAPHS.

BY PROFESSOR H. S. PRITCHETT.*

The photographic testimony as to the form of the Sun's corona, obtained on the occasion of the eclipse of January 1, 1889, exceeds in amount and completeness of detail the results obtained on any similar occasion, with the single exception that the observing parties were confined to a small part of the path of totality.

Of the photographic parties, but three, so far as my information goes, were provided with equatorial cameras, equipped with driving-clock, making long exposures possible. These were the Lick Observatory party at Bartlett Springs, the Harvard College party at Willows, and the Washington University party at Norman, all three places being in the State of California.

Up to the present the only publication of photographic results from these observing parties has been that of the Lick Observatory. The report of the work of the Washington University party is now going through the press. As a large number of the members of the Astronomical Society of the Pacific were engaged in observations of that eclipse, a brief statement of the results obtained at Norman, so far as the form of the corona is concerned, may be of interest.

STATION AND EQUIPMENT.

The Washington University party was stationed at Norman, a small hamlet on the Southern Pacific Railway. The geographical co-ordinates of the station are:

Latitude, - - $39^\circ\ 24'\ 58''.8$

Longitude, - $8^h\ 08^m\ 45^s.39$

* Washington University, St. Louis, Missouri.

The photographic equipment consisted of an equatorial camera, having for its objective one of DALLMEYER'S patent portrait and group lenses of the size known as No. 8 D. The instrument is the property of the U. S. Naval Observatory, and was used in the eclipse of 1878 at La Junta, Col. It has a clear aperture of 6.0 inches, and an equivalent focal length of 37.9 inches. The tube was mounted upon a equatorial stand belonging to one of the five-inch equatorials used in the transit of Venus observations. This stand is very firm; has divided circles on both axes, and was provided with an excellent clockwork. The visual and photographic foci of this lens coincide; the instrument was, therefore, adjusted by the eye, and this adjustment tested by numerous photographic experiments before the day of eclipse. The plates used were SEED'S 26. With these it was found almost impossible to make the tube light-tight without using an automatic shutter. The largest shutter which could be procured in St. Louis was one worked by the ordinary air-bulb, having a clear aperture of 4.5 inches. This cut down the effective aperture of the lens from 6 to 4.5 inches, but probably increased the sharpness of the negatives.

The orientation of the plates was provided for by reading with a clinometer the inclination of the edge of the plate-holder to the horizon.

THE NEGATIVES.

It is manifestly impossible to obtain on a single negative a good representation of both the outer and inner corona. A negative properly exposed for the bright inner corona would be under-exposed for the outer, and *vice versa*. It was decided, therefore, to make exposures of various lengths, from nearly instantaneous up to about thirty seconds. Seven plates were exposed, but the last one was lost by the sticking of the slide in the plate-holder. The length of exposure for each negative is given in the description of the negatives which follows. The photographic equatorial was in the hands of Professors NIPHER and CHARROPPIN. The negatives were developed at Norman by Professor CHARROPPIN. Those of short exposure were lacking in density for printing purposes, but this was rather an advantage than otherwise, as it brought out admirably the details of the filaments and streamers.

Negative No. 1.—This negative, taken immediately after the

beginning of totality, had an exposure of less than half a second. The polar filaments form the prominent feature of the negative. The corona is shown to a distance of three-fourths of a diameter from the sun's disc.

Negative No. 2.—The time of exposure was 3.0 seconds. The polar filaments are a marked feature of this negative, also, the corona being shown to a distance of a diameter and a quarter from the disc.

Negative No. 3.—This negative, which was the first one developed, had an exposure of a little more than six seconds. The equatorial streamers can be seen to a distance of one and a half diameters from the disc. Two large prominences are shown on the western line and five on the eastern line.

Negative No. 5.—This negative had a longer exposure than any of the rest—about twenty-eight seconds. The corona is shown to a distance of more than two diameters from the disc.

Negatives No. 4 and No. 6 of eighteen seconds and thirteen seconds exposure, respectively, differ but little from No. 5.

All the negatives of long exposure show a curious diffraction ring in the center of the black disc of the Moon.

REPRODUCTION FROM THE NEGATIVES.

As just stated, several of these negatives, while very sharp and showing great detail in the structure of the corona, are lacking in density for printing. Furthermore, it is impossible for any one negative to give a fair representation of the entire corona. In the publication of the observations of the Washington University, four of the negatives described above are reproduced by the artotype process.' The negatives chosen for reproduction were those numbered 1, 2, 3 and 5, and include those of short exposure, of medium exposure and that of longest exposure.

It seems desirable to reproduce from the negatives a representative picture which should put into a form capable of study the entire result of the photographic work at this station; a picture, in other words, which should represent the corona as determined by all the photographs taken. The following plan was adopted, at the suggestion of Professor ENGLER:

A positive made from the negative of longest exposure was placed in an ordinary stereopticon, and the image thus produced thrown upon a screen. The lantern was then placed in the position, determined by trial, which gave the best definition to the

image on the screen, and this made the diameter of the Moon's disc about one foot. This image was then copied by hand, in crayon, with great care, by Mr. FREDERICK W. LIPPELT, a most conscientious draughtsman, whose skill in crayon work can hardly be excelled. Each negative was then in turn studied in the same way and under a magnifying glass, and every detail of the corona platted in, taking care to orient each plate properly. All of this work was subjected repeatedly to the criticism of the different members of the eclipse party, and, when completed, was artotyped by Mr. EDWARD BIERSTADT, of New York. This artotype production forms the frontispiece of the present number, and I beg to bring it to the attention of the Society as the definitive result obtained at this station for the form of the corona, a result possessing substantially the accuracy of the original negatives.

In studying this reproduction it is to be noted that the lower edge of the picture corresponds accurately to a horizontal line which is inclined at an angle of 20° 12′.3 to a parallel of declination. This method of orienting the picture was chosen to avoid the necessity of placing reference lines upon the page.

STRUCTURE OF THE CORONA.

It has been stated that the negative of twenty-eight seconds exposure showed the coronal streamers to a distance of more than a degree from the Sun. Señor VALLE, at Norman, using a disc to cover the brighter inner corona, was able to trace the streamers with the naked eye to a distance of more than three degrees. The testimony, therefore, which these negatives are able to supply, does not apply to the fainter coronal streamers outside the smaller limit mentioned above.

The marked structural features of the corona, as presented by the negatives, are [a] the so-called filaments, and [b] the streamers extending approximately in the direction of the ecliptic.

The filaments extend over a region of twenty degrees or more on each side of the poles. They are straight lines of light arranged somewhat like the spines of a fan, and are not radial. The dark spaces between them are not entirely free of coronal matter, but can be traced in some cases to within a short distance of the Sun's limb. Comparing our negatives with a copy of a negative taken by the Lick Observatory party I find the number and arrangement of these filaments to coincide accurately. There

are slight differences in the lengths of some of the filaments, but no greater than might be accounted for by differences of exposure and atmospheric conditions.

The broad and strongly marked equatorial belt stretches directly across this mass of filaments, apparently cutting off the filaments at the somewhat irregular line of separation. The impression conveyed to the eye is that the equatorial stream of denser coronal matter extends across and through the filaments, simply obscuring them by its greater brightness. The effect to the eye is just as if the equatorial belt were superposed upon, or passed through, the filamentary structure. There is nothing in the photographs to prove that the filaments do not exist all round the sun.

The testimony from negatives of different lengths of exposure goes to show that the equatorial streamers are made up of numerous interlacing parts inclined at varying angles to the Sun's equator, but all trending, in a general way, along it, or, roughly speaking, along the ecliptic. The direction and character of these component streamers can be best studied at the edges of the photographs, where, on account of the smaller number shown, their direction and force can be made out. It seems probable that, could we have a faithful reproduction of the extreme outer corona, where individual streamers could be traced out for a considerable distance, our knowledge of the coronal structure would be materially increased.

VALUE OF THE PHOTOGRAPHIC TESTIMONY.

The corona, as projected on the photographic plates, may be described briefly as made up of bright streamers extending across the Sun's equator, surmounted at each pole by fainter coronal matter, traversed by non-radial rectilinear rays, or filaments. A physical and mathematical theory, which will account for this complexity of structure, becomes at once a matter of greatest interest. The resemblance of the polar filaments to the lines of force about a magnet would naturally suggest a discussion upon the basis of a magnetically polarized Sun, did it seem possible to account physically for the existence of magnetic properties under the conditions which are known to exist on the Sun.

The problem of discussing the filaments as lines of force under the assumption of an electrically polarized Sun, is also open to the objection that it is difficult to see how a difference of electrical potential can be maintained upon the solar hemispheres. Such a

theory involves the assumption of some law of the electrification over the Sun's surface.

The force acting upon any point due to such electrification could then be expressed as a function of the co-ordinates of the point. Assuming such an equation of condition and comparing with the observed polar filaments considered as projected upon a plane perpendicular to the line of sight, it is possible to represent the observations equally well by numerous assumptions as to the distribution of the electrification. In fact, the polar filaments on the photographs are too short and uncertain of measurement to serve as the basis of verification of such a theory.

It does not seem easy to explain such an arrangement of matter as that shown in the photographs—assuming the coronal matter about the pole to be actually arranged in convergent lines—on the theory of gravitation alone. The assumption that the so-called polar filaments shown on the photographs are proofs of the actual arrangement of the coronal matter in lines of force, does not seem to me altogether safe. Much of this apparent arrangement may be due to perspective and irregularities in the irradiation and reflection of light.

A phenomenon strikingly suggestive of the polar filaments may be seen by looking, from a distance of a few hundred feet, at an electric light shining through an atmosphere containing large quantities of dust and smoke. The effect of alternating bright and faint streamers is produced by small dust clouds of varying density. Of course, the effect is increased in this case by the fact that the light emanates from a point.

In the absence of a theory of the filaments as lines of force which would commend itself for strong physical reasons, it seems to me that all the testimony of the negatives may be reconciled with the idea that the corona, consisting of almost infinitesimal particles, is made up of matter circulating around the Sun, or gravitating toward it, not ejected from it. Such a view would harmonize with what is known of the zodiacal light, which, it seems to me, must be included in any satisfactory explanation of the corona.

The physical condition of matter in the corona must, in all probability, be similar to that of the matter composing the tails of comets, especially in cases of near approach to the Sun. A study of the behavior of comets in their approach to the Sun will ultimately throw light on the structure of the corona. The tele-

scopic observation of a comet very near the Sun, during a total eclipse, would form an exceptional opportunity.

It must, after all, be conceded that the value of the photographic testimony obtained during this eclipse belongs rather to the future than to the present, and that the negatives then obtained will be of increasing value as they come to be compared with negatives obtained during future eclipses.

SUGGESTIONS FOR THE FUTURE.

It would seem to be a matter of importance that original negatives, obtained during various eclipses should, as years go by, be placed in secure hands where they may be accessible to all astromomers. The National Observatory, which is soon to have a new building, provided with proper vaults, would seem to be the proper repository for such photographic records.

As a result of the study of the photographs of the January eclipse of 1889, the two following points seem to me to demand at present special attention from eclipse observers:

1.—The desirability of obtaining photographs of the outer coronal streamers, whose delineation would doubtless go far toward a real knowledge of the structure of the corona. This involves the problem of designing the photographic outfit specially for this work.

2.—The desirability of photographing the corona from points as widely separated as possible.

In 1871 the corona was photographed from points in India and Java, separated by 2000 miles. The next total eclipse available for observation, occurring April 15–16, 1893, will present a most excellent opportunity for such observations. This eclipse begins in the South Pacific Ocean; is total on the west coast of South America at 0^h Gr. M. T.; is total on the east coast of South America at 1^h Gr. M. T., and crossing the Atlantic the shadow cone reaches the west coast of Africa at 2^h Gr. M. T. The shadow cone first touches the South American continent at Sarco, in Chile, latitude 29° south, and, crossing Chile, traverses the Argentine Republic, passing nearly 400 miles north of Cordoba, and touching the corner of Bolivia, passes directly through Brazil and reaches the Atlantic at Forteleza, in the Province of Ceara, in latitude 4° south. Then, crossing the Atlantic, the shadow cone will arrive one hour later at the west coast of Africa, entering it near Albreda, in Senegambia. It finally leaves the earth at a

point some 2500 miles in the interior, situated in the Great Sahara Desert.

At least one good observing station can be reached in Chile; a number are available in Brazil, and at least one in Africa. Between observations in Chile and those in Africa there would be an interval of over two hours. When it is remembered that the duration of totality will be over 4½ minutes, it will be seen how favorable are the circumstances of this eclipse. Photographs of the corona taken by parties in Chile, Ceara and Senegambia would go far toward solving some of those problems of the corona which seem ripe for solution at the present time. To make the results strictly comparable the photographic equipments should be similar, and the negatives developed by the same operator, using the same method of development.

In the matter of eclipse observation, as in other departments of astronomical work, an intelligent co-operation among astronomers of different nationalities would go far toward increasing the value of the results. The elaboration of some feasible plan for securing co-operation in the observations of this important eclipse might, it seems to me, be very properly undertaken by this Society, which had its practical beginning in the co-operation of observers of the eclipse of January, 1889.

WASHINGTON UNIVERSITY, January, 1891.

LUNAR WORK FOR AMATEURS.

BY THOMAS GWYN ELGER, F. R. A. S.

As it may undoubtedly be assumed that a majority of those who join a Society like this are desirous of undertaking active work of some description, and that all who possess suitable telescopes are anxious so to employ them as to add something, however little, to the general sum of astronomical knowledge whatever branch of observation they wish to pursue,—the following short paper on Lunar Observation may, perhaps, be acceptable to those who are thinking of turning their attention to this promising and attractive subject.

To the observer possessed of a moderate-sized telescope,—*i. e.*, an achromatic of from 4-in. to 8-in. aperture, or a reflector of from 6-in. to 12-in., the study of the Moon's surface